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## Monterey, California

# THESIS

THE PACKARD COMMISSION, A FINANCIAL CRITIQUE

by

Michael Patrick Tryon

December 1987

Thesis Advisor: P.M. Carrick

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# The Packard Commission, A Financial Critique

by

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# I. INTRODUCTION

## A. PURPOSE OF THE THESIS

The purpose and intent of this thesis is to examine from an economic perspective how compliance with MILSPEC and QPL requirements affects the cost of producing integrated circuits. During the course of the research, examination of how compliance with QPLs affects the cost and availability of integrated circuits, financial impact of any performance gains as a result of this compliance, and the validity of costs associated with QPL integrated circuits will be addressed. Finally, a discussion of the financial merits and criticism of the QPL/MILSPEC requirements for integrated circuit procurement, recommendations for possible program alteration, and an evaluation of the Packard Commission recommendation regarding the use of commercially procured integrated circuits in military application.

## B. BACKGROUND

The Department of Defense and to a certain extent private industry are currently facing a dilemma whose repercussions could potentially weaken the military preparedness of the United States. In today's complex world, the edge belongs to the side which has the superior technological base, whether the arena is one of trade or military superiority. The defense of the United States and

indeed, the western world has been built on that technical superiority. Specifically, with the continuing innovations being made by private industry with respect to the unobtrusive integrated circuit, both industry and the Department of Defense (DOD) have realized weapon systems and capabilities that 20 years ago were mere dreams. This rapid expansion in semiconductor technology has allowed for exceptional growth not only in the standard of living but in the offensive and defensive capabilities of the military forces of the United States and its allies. Some of this cushion of superiority is directly attributable to the microscopic integrated circuit.

Almost 30 years ago the neophyte semiconductor market consisted almost exclusively of military and government application. Specifically, the Minuteman II and the Apollo programs were the driving force for new, more advanced technologies. In fact, government procurement of integrated circuits accounted for 95 per cent of that four million dollar market in the early 1960s [Ref. 1:p. viii]. At that time, the industry and government decided that a system of testing should be established to minimize the number of faulty integrated circuits that industry produced and the government procured. As time passed, technology progressed and unit costs were reduced. The semiconductor industry began to realize markets other than the military. This quite naturally led to the industry's realization of

economies of scale. By 1969, the military had observed the growth in the market and decided that a new system for qualification was needed specifically to deal with the increased volume of production of integrated circuits. This was the inception of the Joint Army-Navy (JAN) system, which in addition to encouraging the semiconductor industry to produce larger volumes of integrated circuits for military consumption, also levied an additional battery of production and testing requirements on the manufacturers to ensure continued quality control [Ref. 1:p. ix].

Today, DOD accounts for less than 10 percent of the semiconductor market, according to E. Sonny Maynard, DOD Director of Computer and Semiconductor Technology. By 1990, it is estimated that the DOD market share will increase to approximately 15.5 percent.[1] But as the technology continues to grow and become more complex, and DOD market share of the semiconductor business appears to be rising, so too are the requirements and specifications demanded by DOD of the semiconductor industry. Probably most notable among this myriad of specifications with respect to semiconductors and integrated circuits are the Qualified Products Lists (QPL) and the Military Specification (MILSPEC). It is primarily these two standards which are used by DOD to

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[1]The U. S. Department of Commerce, International Trade Administration estimates 1990 U. S. semiconductor sales at $20 billion. The Semiconductor Industry Association, based on projected DOD budgets, places DOD's 1990 semiconductor requirements as $3.1 billion.

control the variety of integrated circuits produced to meet military requirements. That is, the QPL and MILSPEC describe a common product as the preferred product for a given military situation.

C. DISCUSSION

Contrary to popular opinion, the QPL and the MILSPEC have a viable, identifiable role in the procurement process. They are not and were never intended to be obstacles to hinder semiconductor manufacturers from sharing in the profits available from doing business with DOD in the market place. In fact, the precise definitions are as follow:

> Military specifications are complete descriptions of products which are intrinsically military in character or significantly modified commercial products requiring special features, design, packaging or quality assurance to satisfy military needs. [Ref. 2:p. 13]

> Qualified Products Lists (QPLs) are listings of products which previously were tested to and met specification requirements. Such pre-acquisition evaluation is authorized only for products when there is a requirement for special, extensive test equipment not generally available to a potential manufacturer, or when the time to perform testing to assure acceptability of product design, safety, and quality makes it impractical to conduct the tests after contract award. The process by which products are evaluated is called qualification. The fact that a product is listed on a QPL signifies only that, at the time qualification testing was performed, the manufacturer could make an acceptable product. Normal product and quality assurance testing must still be performed in accordance with specifications and contractual terms [Ref. 2:p. 13].

MILSPEC MIL-M-38510G is the current instruction which establishes the general requirements as well as the quality and reliability assurance requirements which must be met in

the acquisition of semiconductors. The instruction further segregates semiconductors for military procurement into only two classes for product assurance requirements. They are class S and class B. Class S has the highest product assurance level as it is intended for use in space application. Class B is to be used in other than space applications. The aim of the instruction is to spell out in great detail all documentation requirements and qualifications that a manufacturer of semiconductors must conform to if they are to become a supplier of integrated circuits for the government, specifically DOD. Every aspect of performance in the operational environment is described such as operating temperatures, radiation hardness factors and altitude, to name just a few. If an integrated circuit successfully meets all the requirements prescribed in MIL-M-38510G, then that particular product is listed on QPL-38510. Taken in its entirety, the requirements levied by MIL-M-38510G appear to be merely the enforcement of sound engineering practices. Additionally, QPLs enjoy statutory authority as found in U. S. Code 2452.[2] Suffice it to say, both MILSPECs and QPLs have been in existence for some time. As can be readily deduced from the previous definitions, compliance with the MILSPEC for QPL listing is a

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[2]For a historical perspective of the evolution of the QPL, see Naval Postgraduate School Thesis entitled An Assessment of Department of Defense Quality Products Lists, by Lieutenant Commander Robert Vint.

certification process which must occur before a semiconductor manufacturer can attempt to sell integrated circuits to DOD.

The production of integrated circuits is indeed a complex operation. Simply put, the process is as follows. The manufacturer will buy the wafers. The first step then becomes the wafer inspection and cleaning. The wafer is checked by optical microscopy for surface-crystal dislocations. Additionally, it is checked for concavity and convexity as well as thickness. Following the inspection, the wafer is placed in an oxide furnace where the initial thermal oxide is grown. This occurs at a temperature of approximately 1200 degrees Celsius and in an atmosphere of oxygen and hydrogen. This growth stage normally takes between ten and twenty hours. The next step involves the spraying of hexamethyldisilizane (HMDS) onto the wafer. The HMDS is sprayed on and spun off to scrub the wafer free of any particulate contamination which may exist on the surface. It also enhances the adhesion of the photoresist coat, which is sprayed on next. Following this, the wafer is imaged. It is during this stage that the image of the integrated circuit is first placed on the wafer. The wafers are at room temperature during the actual exposing phase. Next, the initial etching takes place using buffered hydroflouric acid at a temperature of 21 degrees Celsius. After the initial etching, the remaining resist is removed

and the wafer is again inspected. This inspection checks for proper etching and measurements of the etched geometry are made to ensure that the initial etching was properly done. It is at this point that the wafer is coated with a thermal gate-oxide growth. This growth occurs at 1000 degrees Celsius in an oxidation furnace. After removal from the furnace, the wafer is then placed in an epitaxial reactor where the polysilicon layer is grown. Next, the mask oxide is grown on the wafer. This occurs again in a furnace at 1100 degrees Celsius. The mask oxide will be used as etching mask for the underlying polysilicon. The wafer is once again coated with photoresist which is applied after the wafer is retrieved from the furnace. The photoresist is then imaged again and the entire wafer is subjected to yet another inspection. This time, the wafer is inspected for pinholes or inclusions which would hamper the ultimate performance of the integrated circuit. The remaining resist is removed and the polysilicon etch is inspected for proper geometry, much the same as before. At this point in the process, the wafer is also inspected for over etching or under cutting of the polysilicon. Following this inspection, Boron ions are imbedded into the wafer. This process is referred to as Boron doping. The doping will alter the electrical characteristics of the underlying silicon to the desired parameters. After the doping, the excess Boron is removed using a bath of hydroflouric acid.

The next step involves the placing of phosphorous doped silicon dioxide on the wafer. This then, completes the doping of the wafer. The wafer is then coated with photoresist, much as before. The resist is imaged again and subsequently etched using hydroflouride etchant. The excess resist is removed and again, the wafer is inspected as before. Included in this inspection also is the search for improper or overlapped contacts within the circuit. The wafer is cleaned and then subjected to vaporized aluminum which covers it. Photoresist is once again applied for the aluminum etching. Following the aluminum etch, the wafer is cleaned and inspected as before. The next coat of photoresist applied is used in the etching of bonding pads. Following the etching, the remaining resist is removed. It is at this point that the integrated circuit is tested against electrical specifications to ensure that it is in proper operating order. The wafer is then packaged. The end use of the circuit will dictate the material used to package the integrated circuit [Ref. 3:pp. 43-61].

The production procedure is the same regardless of the ultimate end use of the integrated circuit, according to Dr. Thomas Longo, President and Chief Executive Officer of Performance Semiconductor Corporation. In other words, there are no special or unique requirements for the production of an integrated circuit for DOD consumption. As noted, DOD currently accounts for approximately 10

percent of the U.S. semiconductor market. Another way of illustrating the point is to suggest that 10 percent of each semiconductor manufacturer's business could be done with DOD. Dr. William J. Perry, Chairman and Chief Executive Officer of H&Q Technology Partners, Inc., and a member of the President's Blue Ribbon Commission of Defense Management and the Defense Science Board, in a keynote address to the Defense Electronics and Military Logistics Forum Symposium on 8 June 1987 eloquently and concisely exposed the dilemma by asserting that "semiconductors are the single most important component that goes into a military system." Yet in his summary he raised the question "is there incentive for the semiconductor industry to go after the military (market)?" Within the industry, there are those in management positions who contend that both MILSPEC MIL-M-38510G (Military Specification microcircuits, General Specification For) and the entire QPL process are too costly and really not necessary. The industry's contention is that U. S. commercial semiconductor quality levels exceed levels required by government specifications [Ref. 1:p. x]. By the Defense Product Standards Office's (DPSO) own assertion, a semiconductor manufacturer could spend anywhere from $5000 to $100,000 for qualification testing alone. These figures are more accurately reflected as being between $50,000 and $100,000 when qualifying to a high performance specification such as MIL-M-38510G [Ref. 4:p. 1]. In response to the

industry's quality contention, Mr. Daryl Hill, QPL Division Director, QA Department, Defense Electronics Supply Center (DESC) asserts that in his experience, he has never encountered a situation where a manufacturer of semiconductors and integrated circuits has produced an off the shelf product which compared favorably with a QPL integrated circuit. And so the battle lines appear to be well defined.

D. SUMMARY

Over the past 30 years, DOD has seen itself move from the position of being the largest consumer of semiconductors accounting for 95 percent of the market to a small corner of the industry, currently accounting for approximately 10 percent. As the semiconductor industry has expanded its capabilities and technological base, DOD as a consumer has continued to insist upon rigid adherence by producers to MILSPEC and QPL criteria for their integrated circuits. While there are specific areas where particular testing on made-to-order integrated circuits are required, such as in space and nuclear applications, the industrial consumers of integrated circuits contend that they have come to demand standards and manufacturing processes equivalent to the military [Ref. 5:p. 61]. Is it then accurate to assume that both DOD and industrial consumers of integrated circuits are demanding and in fact obtaining identical products but at widely different costs? Is the process of building and

qualifying integrated circuits as required by DOD a paradigm for the semiconductor industry to emulate?

## II. COMPLIANCE WITH QUALIFIED PRODUCTS LIST PROCEDURES THE IMPACT ON COST AND AVAILABILITY

### A. INTRODUCTION

This chapter will endeavor to explore how conformity with the procedures required to place an integrated circuit on a QPL impact on the cost and availability of the item. As might be surmised, the Defense Electronics Supply Center (DESC) is the key player in the QPL certification process. While Rome Air Development Center (RADC) is actually the supervising or approving agency for the preparation of MIL-M-38510, DESC is the agent charged with the administrative specification writing function. In addition to the management of the QPL, DESC also is responsible for objectively certifying semiconductor companies and products to be listed on a QPL. This seemingly innocuous accomplishment is anything but that. The lengthy process by which an integrated circuit is placed on a QPL signifies nothing more than the fact that a manufacturer could make an integrated circuit that met the specification requirements. In reality, the listing of a product on the QPL:

a. Does not in any way relieve the supplier of it's contractual obligations to deliver products that comply with all specification requirements.

b. Does not guarantee acceptability of products delivered under a contract.

c. Does not constitute a waiver of any requirements for inspection, for process control, or for maintenance of quality control procedures during production.

d. Does not in any way relieve the Original Equipment Manufacturer (OEM) of its' contractual obligations to ensure that delivered products (including the qualified products used in the equipment) comply with all specification requirements. [Ref. 6:p. 4]

In essence, for a semiconductor manufacturer to be listed on a QPL means little more than that particular manufacturer is recognized as an authorized source of JAN semiconductors.

## B. THE QUALIFICATION PROCESS AND ASSOCIATED COSTS

### 1. DOD Requirements and Perspective

The qualification process for a semiconductor manufacturer begins with Phase 1, the audit of the manufacturer's facility by a DESC audit team normally consisting of one wafer fabrication engineer and one assembly/test engineer [Ref. 7:App. 1]. This is also known as certification and occurs at the manufacturing facility. Phase 2 commences with the submission of an application for qualification. In addition to the normal, administrative details such as the number and date of specification under which tests are desired, and the type and designation of the integrated circuit, the applicant (manufacturer) also agrees to a certification in which the applicant:

(1) Agrees to be bound by all of the provisions and terms set forth in SD-6 (Provisions Governing Qualification, (QPLs)).

(2) Is the manufacturer of the product or a distributor authorized by the manufacturer to distribute the product with the manufacturer's brand or to re-brand and

distribute the product under his own brand and designation. A distributor who re-brands shall furnish certification from the actual manufacturer that he is authorized to re-brand and distribute the product with his own brand designation.

(3) Has determined from actual tests (within the limits of test equipment commonly available, unless otherwise specified) that the product conforms to application specification. (Test reports and data should be furnished with the application.)

(4) Shall supply items for test which are samples from the manufacturer's normal production.

(5) Shall supply products which meet the requirements of the specification in every respect.

(6) Shall overcome deficiencies disclosed by qualification testing.

(7) Shall not apply for re-test of the product until satisfactory evidence is furnished that all of the defects which were disclosed by previous tests have been corrected. (Test reports may be required as evidence.)

(8) Shall not state or imply in advertising or otherwise that a product, which has received DOD qualification approval is the only product of that type so qualified, or that DOD in any way recommends or endorses that product.

(9) Shall notify the responsible activity of any change in design, material, manufacturing process (including quality control), or plant location after qualification approval.

(10) Shall submit a Certification of Qualified Products (DD form 1718) signed by the responsible official of management, attesting that the listed product is still available from the listed plant, can be produced under the same conditions as originally qualified, and meets the requirements of the current issue of the specification.

(11) Shall include provisions for self audit of the processing, fabrication, assembly, inspection and testing of the product. The results of the self audit program, which promptly reports deviations and corrective action to management, shall be made available upon request.

(12) Has and will maintain effective management for quality, clearly prescribed and documented by the manufacturer.

(13) Shall submit a statement signed by a responsible official of management that if the product has been removed from the QPL, the manufacturer shall take the responsibility of notifying its customers and distributors within 3 working days of notification of removal.

(14) Agrees to provide the government access, upon request, to technical records, personnel, and facilities pertaining to the manufacturing, processing, inspection and testing to assure compliance with all specification requirements. [Ref. 6:pp. 7-8]

Upon receipt of all information required by SD-6 in the application for certification, a letter authorizing the manufacturer to conduct qualification testing is issued, normally by DESC. The cost for the certification and qualification procedures thus far have been borne by the manufacturer, with the exception of the DESC engineers. SD-6 is very clear in paragraph 201:

Costs. Samples for testing shall be supplied by the applicant at no expense to the Government. The costs of the tests to be borne by the applicant, will be stated in a letter authorizing the tests. The Government will not be responsible for any expense resulting from shipment of the samples to or from the laboratory, damage during the test, or damage or loss of sample while at the laboratory.

From the DESC viewpoint, qualification of an integrated circuit for QPL-38510 costs the manufacturer between $10,000 and $50,000. In spite of the requirement that an integrated circuit to be tested for QPL-38510 qualification must be manufactured entirely in the United States, this does not appear to be where the bulk of the costs to the manufacturer lies, according to DESC [Ref. 8:p. 6]. Neither does it fall under the heading of testing, specifically destructive versus non-destructive. According to one DESC estimate, as

many as 200 of the model integrated circuit may be needed to comply with all testing requirements. Of this lot, perhaps four or five will be destroyed. Thus, destructive testing does not appear to be the cost culprit. It is the contention of DESC that the major cost to the manufacturer is in the fabrication of what is known in the business as the test tape. The test tape is either a tape or the software required to program the test equipment to be used in electrically checking the circuit for performance as required by MIL-M-38510. The test tape contains the required parameters that the circuit should meet in order to qualify for inclusion on QPL-38510 listings. It enables the tester used to accurately check the circuit.

Ostensibly, the costs incurred by a manufacturer (in terms of both time and dollars) in qualifying an integrated circuit for listing on QPL-38510 would appear to have a direct and negative impact on the availability of integrated circuits in general. National Semiconductor for example takes approximately eleven months to produce an integrated circuit for QPL 38510 listing. In spite of time frames such as mentioned above, DESC asserts that compliance with QPL procedures actually enhances the availability of QPL-38510 integrated circuits [Ref 9:p 25]. The improved availability as well as improved lead times are a result of manufacturers adhering to qualification procedures required to place integrated circuits on QPL-38510. Thus, when

demand occurs, circuits listed on QPL-38510 are available for immediate procurement because the manufacturer has already qualified that specific circuit. Problems with availability and lead times, according to DESC, in reality occur when a requirement exists for a particular type of integrated circuit which is not listed on the QPL. In this case, the manufacturer must go through a lengthy qualification and testing procedure which leads to the production of the first integrated circuit of that particular type. This problem is known as first article testing and certainly exacerbates any availability or lead time problems which might already exist.

2. The Industry Viewpoint

Unlike DOD, the private sector operates their businesses on the bottom line or profit motive basis. The maximization of profit and the minimization of cost therefore, play a major role in corporate planning [Ref. 10: p. 153]. This is not meant to imply that cost is an insignificant concept to DOD. By virtue of a semiconductor manufacturer running on a profit motive and DOD operating essentially as a not for profit organization, the concept of cost takes on very different perspectives. National Semiconductor, if not the largest, is certainly one of the largest suppliers of integrated circuits to DOD and as such is assumed to be representative of the industry. By their own admission, all that DOD is requiring in MIL-M-38510 is

sound engineering practice [Ref. 11]. National Semiconductor's contention is that the high cost of an integrated circuit manufactured in accordance with MIL-M-38510 is not due to the fabrication of the test tape as asserted by DESC. Rather, their contention (which appears to be the general consensus of the industry) is that the high cost is directly attributable to the extensive documentation required for the certification of the integrated circuits as prescribed by MIL-M-38510. The documentation required by most all commercial users is limited to a certificate of conformance for the product while military documentation requirements are more stringent [Ref. 12:p. 116]. Details relating to the break out between commercial and MIL-M-38510 class S and class B test documentation are located in the appendix.

In actuality, the cost of qualifying an integrated circuit in accordance with the appropriate MILSPEC will vary slightly depending on the manufacturer. Ostensibly, the cost of certification and qualification will likewise have a much different impact on the manufacturer. Factors such as company size and the facilities available to them will play a direct role in the significance of this cost. National Semiconductor, Military Programs Branch recently estimated the cost of certification of both class S and class B integrated circuits. Their cost structure appears as follows.

| | | class S | class B |
|---|---|---|---|
| **Military Programs** | ($150/day) | $8.35K | $7.5K |
| generate/update baseline,specs,etc. | (7 days/$1K) | | |
| program plan | (2 days/$.3K) | | |
| document control | ($1.5K) | | |
| coordination/mtgs | (5 days/$.75K) | | |
| **class S requirements** | **($.75K)** | | |
| travel | (3 trips/$3K) | | |
| DESC audit | (3 days/$.9K) | | |
| **QA Audit** | ($300/day) | $5.3K | $5.3K |
| pre-audit | (6 days/$1.8K) | | |
| corrective action | (2 days/$.6K) | | |
| DESC audit | (3 days/$.6K) | | |
| travel | (2 trips/$2K) | | |
| **Product Group** | | $9.155K | $6.65K |
| training | | | |
| trainer | (160 hrs @ $15/hr=$2.4K) | | |
| operator | (30 hrs @ $8,5/hr=$.25K) | | |
| spec updates | (40 specs @ $26/hr=$1K) | | |
| technical | ($1K) | | |
| mtgs/instructions | ($1K) | | |
| **class S traceability** | **($2.5K)** | | |
| DESC audit | (3 days/$1K) | | |
| **Assembly and Test** | | $16K | $12.1K |
| **TOTAL** | | **$38.8K** | **$31.55K** |

National Semiconductor accounts for the difference in the assembly and test figures between class S and class B by stating that the class S figure includes several test requirements unique to class S product qualification. Additionally, they opine "that the costs detailed above are considerably lower than what has been considered reasonable costs by the industry." They further state that "apparent discrepancies are accounted for by the indirect investments in the military support systems within National

Semiconductor for many years (e.g., QA audit, quality control systems, military programs admin etc.)" [Ref 13].

The industry's 'hobby horse' continues to be the contention that the documentation required by MIL-M-38510 is the culprit which drives up the cost of QPL-38510 integrated circuits. As can be seen by the figures (which are approximate) provided by National Semiconductor, Mil/Aero Branch, under the heading of Product Group there is a separate category delineated for class S integrated circuit documentation. The cost differential between the class B and the class S figures for the Product Group heading appear to be directly attributable to the degree of control and traceability required by the class S device. While the documentation requirements for class B devices required by MIL-M-38510 take effect during the assembly phase of the circuit's production after the wafer has been screened, those same requirements become effective for the class S circuit much earlier in the production process. In fact, documentation on a class S circuit begins almost with the raw silicon [Ref. 12]. Under the heading of Military Programs as well there is a separate category delineated for class S circuits.

As an example, National Semiconductor maintains their facility for manufacturing QPL-38510 devices in Tucson, Arizona. With the exception of one other facility located in the United Kingdom, all other manufacturing

capability is located in the Far East. Since the Tucson facility is dedicated to JAN production, availability of QPL-38510 integrated circuits does not appear to be a problem. For a company the size of National Semiconductor, by their own admission, the cost of qualification/ certification associated with MIL-M-38510 requirements is not significant. This would appear to be in concert with the opinion expressed by DESC. The very fact that National Semiconductor is able to meet and produce in accordance with the rigid specifications of MIL-M-38510 is a significant marketing tool. This ability presents the company in an extremely favorable light to it's other non-military customers. Apparently, this externality has been good for business at National Semiconductor and has probably had the same affect on others in the industry as well [Ref. 13].

The significant cost to the manufacturer of QPL-38510 integrated circuits would appear to lie elsewhere. While all other production capability for National Semiconductor has gone off shore, they must bear the cost of supporting one facility located in the United States dedicated to producing QPL-38510 integrated circuits. The manufacturing of these devices obviously requires skilled employees and at the Tucson plant, National Semiconductor employs approximately 700 people. So it would also appear obvious that the savings realized in labor costs for other sectors of the integrated circuit business would not apply

to QPL-38510 circuits as they are required to be manufactured domestically where labor costs are significantly higher. This is true in the case of National Semiconductor and probably true industry wide.

Yet another factor contributing heavily to the cost of manufacturing either class S or class B integrated circuits is the comparatively small number of circuits produced for DOD consumption each year. In a typical year, National Semiconductor will produce approximately 20,000,000 circuits for industry while producing only 100,000 circuits for DOD. Manufacturing for private industry thus yields a 200-to-1 advantage for National Semiconductor and ultimately for commercial consumers. That is, the depreciation and amortization of fixed costs associated with the production of the circuits for commercial industry by National Semiconductor over a base of 20,000,000 products will obviously lower the unit production cost [Ref. 14].

## C. SUMMARY

The cost of a QPL-38510 integrated circuit is, without argument, higher then that of a commercial integrated circuit. While the industry in general continues to assert that this higher cost is due to the documentation required by DOD, DESC's contention is that the cost is in the fabrication of the testing software for the individual circuit. Further, while both of these factors add to the price of the QPL-38510 integrated circuit, neither by itself

would appear to be the sole reason behind the higher price. By all accounts, it does not appear that the costs associated with the production of the QPL-38510 circuits directly affects their availability. The major cost associated with this type of circuit seems to stem from the maintenance of a domestic production facility in which the JAN circuits are manufactured. Another contributing factor is low volume production runs requiring the allocation of significant amounts of annual fixed costs at the Tuscon plant over a relatively small number of units produced.

## III. THE PERFORMANCE OF QPL INTEGRATED CIRCUITS

### A. INTRODUCTION

Performance, according to the American Heritage Dictionary, definition number three, means "the way in which someone or something functions." Performance, in and of itself, is nothing more than the execution of a function or the output of a person or thing. A popular connotation of the word performance is to equate it with concepts such as outstanding or excellent. This misconception is rapidly brought into context with the idea of a measure of effectiveness (MOE). Performance is not inherently good or bad. It is merely output. The qualitative assessment is determined by the measure of effectiveness selected for use in gaging an item's performance. The purpose of this chapter will be to explore the performance of QPL-38510 integrated circuits vis-a-vis integrated circuits intended for commercial use in an attempt to discover if there is a resulting performance gain with the QPL-38510 devices and to discuss the financial ramifications of such a performance gain.

### B. QUALITY AND RELIABILITY

MIL-M-38510 is the MOE currently used by DESC to qualitatively evaluate integrated circuits. In light of the previous statement then, quality, for purposes of this

thesis, will be defined as the suitability of an integrated circuit to a specific task. Logically, reliability will be defined as quality over time. Performance as addressed in this thesis therefore, has two component parts, quality and reliability. Before an integrated circuit can be evaluated in terms of reliability insofar as DESC is concerned, it must have met the quality criteria as delineated in MIL-M-38510G. The remaining discussion and comparisons in this chapter will deal primarily with a certified QPL-38510 (class S or class B) MILSPEC part and the non-military (commercial) part.

According to data obtained from DESC, approximately 77% of the integrated circuits procured by DOD are those which have completely met MIL-M-38510G criteria [Ref. 9]. The latest data available from DESC compares results of fiscal years 1980 through 1984 quality and reliability testing. Once procured, both the MILSPEC part and the non-MILSPEC part are examined by DESC for both quality and reliability. The semiconductors are normally inspected at the plant by lots as they are procured. Only after they are examined is a determination made as to whether or not the lot will be accepted. Further analysis can then be conducted on discrete parts for the purposes of data collection. With this discussion in mind, the following data tables are presented.

TABLE 3-1

NON-MIL LOT REJECTION RATE
(discrete lot data)

| | |
|---|---|
| FY82 | 47.6% |
| FY83 | 33.5% |
| FY84 | 30.4% |

As can be seen in Table 3-1 above, the DESC rejection rate for semiconductors not manufactured in accordance with MILSPEC parameters is high. The basis for rejection of these common devices is the comparison of these devices with the lowest quality level recognized by RADC. That is class D-1. The assignment of classes (B-1, B-2, D, D-1) below class B by RADC is arbitrary and indicative of certain portions of the MILSPEC which may have been met by a commercial integrated circuit. These particular devices are also known as consumer circuits, plastic seal. In other words, these are termed off-the-shelf hardware [Ref. 15]. The declining trend illustrated in Table 3-1 would appear to be indicative of tighter manufacturing quality control.

Table 3-2 is much more illustrative in terms of failure rates between QPL-38510 devices and other devices. The implicit financial implications should be obvious. Clearly stated, the true cost of a device such as an integrated circuit does not lie in the procurement price tag, although that price comprises part of the cost. The cost of having

TABLE 3-2

FAILURE RATES
(discrete part data)

| | Mil Part Failure Rate | Non-Mil Part Failure Rate |
|---|---|---|
| FY80 | 1.3% | 9.1% |
| FY81 | 1.0% | 13.6% |
| FY82 | .99% | 15.0% |
| FY83 | .91% | 7.7% |
| FY84 | .94% | 9.6% |

to replace a non-military part more frequently to meet the operating tempo of the specific equipment should be added to the procurement cost for accurate comparison. One facet of this comparison upon which it is difficult to place a monetary cost is on the reliability of the equipment. Recall the earlier definition of reliability as being quality over time. It would appear from Table 3-2 that utilization of the MILSPEC circuit would make the equipment inherently more reliable. Additionally, the cost of repair of the equipment is greater using a non-military circuit as a new circuit must be installed upon failure of the old.

Perhaps the most convincing data of all are found in Table 3-3. The most significant line of data in that table is the ratio. In 1983, for every 1 JAN part that was tested and failed, 15 non-military devices were tested and failed. Likewise in 1984 the ratio is 1 to 21! In light of the aforementioned definitions of quality, reliability and the

TABLE 3-3

PRESENT QUALITY LEVELS
(discrete part data)

| | FY83 | | FY84 | |
|---|---|---|---|---|
| | *JAN | NON-MIL | *JAN | NON-MIL |
| No. tested | 3837 | 9331 | 2686 | 9171 |
| No. failed | 20 | 717 | 12 | 881 |
| % failed | .52 | 7.7 | .45 | 9.6 |
| **RATIO** | **1 TO 15** | | **1 TO 21** | |

*FSC 5961(semiconductors)[Ref. 9:p. 30]

general concept of performance, the non-military circuit is, statistically, not as reliable as its MILSPEC counterpart. Thus the performance of the MILSPEC device would seem to be clearly superior.

In an attempt to quantify the quality attached to an individual class of integrated circuits, Rome Air Development Center (RADC) located at Griffiss Air Force Base, New York developed a quality factor known as (pi)Q. This factor is the result of an empirical derivation from fielded hardware [Ref. 16]. That is, RADC has collected failure rate data for MILSPEC and non-MILSPEC integrated circuits in an attempt to arrive at a statistical quality comparison. (Pi)Q is a quality factor used to rate integrated circuits by JAN class. The (pi)Q factor is published in MIL-STD-217. The magnitude of the factor corresponds to the reliability of the integrated circuit as

experienced in field applications. A small (pi)Q is indicative of a high quality circuit. Conversely, a large (pi)Q is indicative of a low quality circuit. Table 3-4 illustrates (pi)Q factors across all classes of integrated circuits and is the proposed update to be included in the new MIL-STD-217. Further discussion concerning the derivation and background of the (pi)Q factor is beyond the scope of this thesis.

TABLE 3-4

(PI)Q FACTORS

| (pi)Q | Quality Level | Description |
|---|---|---|
| .25 | S | class S |
| 1.0 | B | class B |
| 2.0 | B-1 | Mil 883 compl.[3] |
| 5.0 | B-2 | Mil 883 compl.[4] |
| 10.0 | D | Industrial |
| 20.0 | D-1 | Consumer [Ref. 15] |

The information presented in Table 3-4 appears to be consistent with the information presented in Tables 3-1/2/3. Two apparent areas of significance appear with juxtaposition

[3]MIL 883 is the DOD Test Methods and Procedures for Microelectronics.

[4]The difference in (pi)Q between B-1 and B-2 is due to the DESC audit being required for B-1 but not for B-2.

of all four tables. First, Table 3-4 also presents those integrated circuits not manufactured and certified in accordance with MIL-M-38510G as being significantly less reliable than the QPL-38510 devices based on empirical data gathered by RADC. Of greater significance is the fact that not one, but two separate, distinct and exclusive agencies have both consistently arrived at the same conclusions. In spite of the fact that both agencies are organic to DOD, DESC and RADC use MIL-M-38510G as the measure of performance enumerated by DOD and both agencies achieved the same results with respect to the reliability of commercially procured integrated circuits. That is, QPL-38510 integrated circuits enjoy a distinct and significant gain in performance as opposed to non-military devices.

## C. FINANCIAL IMPLICATIONS

When viewing the financial impact of utilizing QPL-38510 integrated circuits versus those integrated circuits not QPL-38510 listed, other cost factors ostensibly enter the problem. Not only should procurement cost be considered but labor to repair or replace the equipment as well as the cost of equipment redundancy to cover for the downtime of the equipment should be included. Additional costs could include increased inventory, procurement, and holding costs to ensure enough of the non-military devices are on hand to meet failure rates. The data presented in the previous tables clearly shows that there exists a significant gain in

performance between the QPL-38510 integrated circuit and the non-military circuits. This factor is significant because in spite of a class S device typically costing twice as much as a look-alike non-military device, that procurement cost is not representative of the true cost of using a MILSPEC part vis-a-vis a non-MILSPEC part [Ref. 14]. The reliability, quality and performance data gathered by both DESC and RADC have lead to DESC opining the following.

> Cost considerations. Microelectronic devices should be selected on the basis of overall life cycle cost considerations rather than initial procurement cost alone [Ref. 17:p. 3].

This opinion (soon to become a requirement) would seem to deal a rather debilitating blow to the already suspect contention by the semiconductor industry with regard to why a QPL-38510 integrated circuit has such a high procurement cost.

While from a business standpoint it would make sense to utilize the less expensive integrated circuit, QPL-38510 devices are often employed in equipment where part failure could spell imminent death and/or result in extraordinarily costly equipment losses for the user of that equipment. While there are those within the industry who contend that the reliability difference between a QPL-38510 device and a commercial device is not worthy of the additional cost, those who are ultimate end users of equipment containing QPL-38510 integrated circuits, and the military establishment in general, continue to take umbrage with such

contentions [Ref. 18]. The need for QPL-38510 has been re-emphasized from within the Office of the Secretary of Defense. Two reasons that a device would be placed on the QPL would be because the integrated circuit is a critical safety item or because the device is critical to the mission being performed such that failure of the integrated circuit could lead to circumstances resulting in death to the user [Ref. 19]. In other words, while industry "might" be willing to accept the potential for loss of human life in the name of cost savings, the Government and DOD in particular, appear very reluctant to do the same.

D. SUMMARY

While it is true that in the population of integrated circuits there exist those devices mistakenly referred to as equivalents of the class S or class B integrated circuits, the quality, reliability, and performance of these similar products are not the same as the QPL-38510 products. RADC and DESC have independently and in some cases, jointly, collected and collated data which objectively proves that **there is a significant performance gain with the QPL-38510 circuits vis-a-vis their commercial counterparts.** That difference in performance lead RADC to attempt to quantify it utilizing what is known as the (pi)Q factor. This quantification of performance used empirical data from fielded operating systems to arrive at a measure of reliability. In all cases, commercial grade integrated

circuits have performed at a level where the (pi)Q values assigned them consistently place them at the low end of the reliability spectrum. Additionally, the (pi)Q values assigned do not appear to differ significantly between suppliers of commercial grade integrated circuits [Ref. 20].

The financial implications are clear. Initial procurement cost should not be used to compare QPL devices with commercial devices. Rather, the overall life cycle cost should be utilized. In that light, QPL-38510 integrated circuits appear not to be so expensive after all.

## IV. A DISCUSSION OF MILITARY SPECIFICATIONS: ARE THEY JUSTIFIED?

### A. INTRODUCTION

The purpose of this chapter is to discuss military specifications, focusing on MIL-M-38510, in an effort to ascertain if the cost of production and ultimately procurement of QPL-38510 devices is justified by the results achieved. The crux of this discussion deals with perceptions based on performance. While the semiconductor industry's viewpoint will be considered, the larger portion of this discussion will of necessity center around the opinions expressed by RADC, which is responsible for publishing the specification and DESC, which uses the specification ostensibly as a measure of effectiveness in the evaluation of QPL-38510 integrated circuits. The discussion is so weighted because DOD is the end user of the integrated circuits produced in accordance with MIL-M-38510G and as such, is in a more reasonable posture to render opinions on the justification of procurement costs.

### B. DISCUSSION

As altruistic as the semiconductor industry may seem with respect to the price of a class S or class B integrated circuit, their concern is the maximization of profit by individual manufacturers. That is, holding the current

procurement price fixed, how can a semiconductor manufacturer lower production costs? It follows logically that if production costs are lowered while procurement prices are held constant, profits will increase. While the issue of streamlining the MILSPEC/JAN system is beyond the scope of this thesis, the semiconductor industry is currently engaged with both RADC and DESC to reduce the requirements by which current class S and class B integrated circuits are manufactured and tested. It would appear that any reduction in requirements would decrease the cost of production for the manufacturer. Although the industry espouses that any savings realized by reduced production costs could be passed along to DOD customers, there is no information available which would indicate what portion of those savings would in fact accrue to DOD. A semiconductor manufacturer operating as a going concern would obviously attempt to improve its own future profit picture over its current profit picture. In other words, the manufacturer benefiting from the reduction of manufacturing requirements for class S and class B integrated circuits would in all probability pass along some amount of savings to DOD in the form of lower procurement costs but the savings realized by DOD would probably not be proportional to the savings realized by the manufacturer.

As the old adage says, where one stands depends on where one sits. This is particularly true in the case of

reliability as perceived by private industry vis-a-vis RADC and DESC. In his address to the Defense Electronics and Military Logistics Forum on 8 June 1987, Dr. Thomas Longo compared the cost of a cheaper integrated circuit which had no documentation or special test requirements and a QPL-38510 class B circuit. In his presentation he opined unequivocally that the increase in reliability demonstrated by the class B integrated circuit was not worth the cost to DOD. Dr. Longo's position in this regard is shared by many within the semiconductor industry. That position stems from the very nature of the semiconductor business. That is, increased reliability of an integrated circuit at a nominal cost. This typically business approach appears to work well with other commercial customers, but not with DOD.

Two major and distinct differences exist between DOD and the commercial semiconductor customer. First, as previously mentioned, DOD is not profit motivated in the same sense a private industry is. Second, the environments in which DOD operates require integrated circuit parameters that can be so unique as to not be found in private industry. Interwoven into the question of cost versus reliability is the notion that while private industry can weigh the litigious costs resulting from injury or death as a result of an integrated circuit malfunction against profits earned through sales of the same integrated circuit, DOD is subjected to an unquantifiable public perception that for

critical integrated circuits (class S or class B), reliability must be as close to 100% as possible, cost notwithstanding.

In developing MIL-M-38510, RADC defines the scope of this particular specification as follows:

> This specification establishes the general requirements for monolithic, multichip, and hybrid microcircuits and the quality and reliability assurance requirements which must be met in the acquisition of microcircuits. Detail requirements, specific characteristics of microcircuits, and other provisions which are sensitive to the particular use intended shall be specified in the applicable device specification. Multiple levels of product assurance requirements and control for monolithic and multichip microcircuits and two levels for hybrid microcircuits are provided for in this specification. [Ref. 8]

This specification, along with its supplements and amendments is a document whose thickness exceeds one inch and details, down to the most minute facet, the performance parameters for class S and class B devices. Indeed, it has been shown by both RADC and DESC that exact compliance with the requirements of the specification results in a significantly more reliable integrated circuit. The depth to which MIL-M-38510G goes is necessary to provide the exact desires of DOD with respect to the type of integrated circuit, i.e., class S and class B. Adherence to the specification protects the manufacturer in that the requirements and parameters found in MIL-M-38510G alleviate any guess work on the part of the manufacturer insofar as the desired end product is concerned. That is, if a manufacturer produces an integrated circuit that meets or

exceeds all requirements delineated in MIL-M-38510G and that particular circuit is not what DOD desires, then the liability for the manufacturing of the wrong type of device lies with DOD and not the manufacturer.

The question of MIL-M-38510G justifying the cost of a QPL-38510 integrated circuit was answered with a resounding yes from all quarters of RADC and DESC. As previously illustrated in Chapter III, there is a significant increase in the reliability of a QPL-38510 integrated circuit vis-a-vis a commercially procured integrated circuit. As an example, at a Navy Industrial Fund (NIF) activity such a shipyard, approximately 85% of any given job is direct labor cost and approximately 15% is material cost. Assuming a labor rate of $25 per hour, it is intuitively obvious that even a small gain in reliability will result in cost savings to DOD [Ref. 21]. So, adherence to MIL-M-38510G not only provides the most reliable integrated circuit but will result in cost savings over a longer period of time. Mr. Louis Terhune, Director of Technical Evaluation at DESC holds the very strong opinion that MIL-M-38510G justifies the cost of a QPL-38510 class S or class B circuit if for no other reason than the government (DOD) knows exactly what it is asking for [Ref. 22]. From this position, DOD can hold the manufacturer liable if the parameters and requirements of MIL-M-38510G are not met. In an engineering sense, without this particular specification DOD would have to rely

on the data provided by the manufacturer. This indeed, would make it extremely difficult if not impossible to question the performance, reliability and almost every other aspect of a manufacturer's integrated circuit data.

Mr. Ed O'Connell, Assistant Chief of the Microelectronic Reliability Division at RADC, is of the opinion that MIL-M-38510G is very cost effective. His opinion, which is RADC's position, is based on the fact that the quality of a QPL-38510 device is much better as compared to a commercial device and that the probability of greater longevity with a QPL-38510 device is significantly higher. Furthermore, if commercial devices were used, DOD would have to maintain a parts inventory to support the requirement [Ref. 20]. That inventory would have to be, of necessity, extremely large in order to accommodate the myriad of integrated circuits needed to support DOD requirements.

The Chief of the Microelectronic Reliability Division at RADC, Mr. Joseph Brower, likewise holds very strongly that MIL-M-38510 is absolutely necessary. Speaking as an engineer, Mr. Brower alluded to the fact that the specification is nothing more than sound engineering practice. Of note, Mr. Brower was directly involved in discussions with the Defense Science Board Summer Study Group 1986. During his discussions with this distinguished board, a very disturbing fact was surfaced with regard to the Packard Commission and the recommendation to use

commercially procured integrated circuits in military application. Although not stated explicitly in either the Defense Science Board report or the Packard Commission report, both documents allude to the fact that the fundamental concept of both bodies was based on the example of the ruggedized integrated circuit used in the automotive industry. While not measuring up to the performance of a class S or class B device, those within the semiconductor industry contend that by utilizing this particular device in lieu of a class S or class B integrated circuit, DOD could essentially eliminate MIL-M-38510 and thus QPL-38510 devices. In his discussions with the Defense Science Board members, Mr. Brower discovered that like the Packard Commission, they too, were using the Delco (automotive) example, extrapolating the results and attempting to apply those results to DOD. The fallacy of this logic is that in fact, Delco procures approximately 35 different integrated circuits annually. Of those 35, only 8 or 9 integrated circuits are procured in extremely large quantities. This implies that in their end product, Delco really has call to use about 8 or 9 different integrated circuits and that end product has a limited number of functions [Ref. 16]. Given the extreme diversification of operational requirements faced by DOD, it would appear that a strong case can be made for the MILSPEC and particularly MIL-M-38510. The arguments of both the Packard Commission and the Defense Science Board

seem relatively insignificant upon the juxtaposition of Delco requirements and DOD requirements.

C. SUMMARY

While there are those from the private sector who continue to insist that they know exactly what DOD needs in terms of integrated circuits and how to produce them, both RADC and DESC continue to document examples which refute those insistencies. Performance to date continues to reveal a distinct and significant difference in reliability and quality between the QPL-38510 devices and the commercially procured devices. And while private industry continues to argue against the cost of providing increased reliability as a result of compliance with MIL-M-38510, DOD is without that luxury. Further, DOD is subjected to an unquantifiable public perception that integrated circuits, like every other piece of military equipment, should be the most reliable that money can buy. The discussions concerning the possible elimination of MILSPECS, particularly MIL-M-38510, appear to have been motivated by the private sector to increase their profit potential while at the same time, reducing their accountability. The use of commercially procured devices would mandate that DOD carry inventories of those devices to prevent the expenditure of millions of dollars for re-procurement <u>after</u> a vendor has discontinued that integrated circuit from his line. Above all, MIL-M-38510 provides a point of known reference for DOD. MIL-M-38510 has proven

itself to be justified not only through cost effectiveness but through providing for greater longevity in QPL-38510 devices.

# V. CONCLUSION

## A. INTRODUCTION

The purpose of this final chapter is to summarize the findings of the thesis and relate those findings to the Packard Commission recommendation to use commercially procured integrated circuits in military application. There are in fact, two sides to every story. DOD's emphasis in the area of class S and class B integrated circuits has been and continues to be maximum reliability, quality and performance. Qualifying an integrated circuit in accordance with MIL-M-38510 and subsequent listing on QPL-38510 has been the vehicle by which DOD has ensured that the desired parameters have been met by the manufacturer. Additionally, this method has continued to ensure a readily available supply from various semiconductor manufacturers of class S and class B devices, thus limiting to an absolute minimum, situations where availability of a class S or class B integrated circuit is limited. While the semiconductor industry in general continues to insist that their quality standards are congruent with those of DOD, the very fact that the operating parameters required by DOD in MIL-M-38510 are more rigorous than those found in industry would tend to weaken the industry's contention and render inert the idea that commercially procured integrated circuits are as high a

quality as a class S or a class B device. The industry's attempt to build a better 'mousetrap' is laudable, however, established DOD standards should not be compromised in order to placate those within the semiconductor industry or within the government itself.

## B. THE PACKARD COMMISSION RECOMMENDATION

While on the surface the proposal to use non-developmental items or commercially procured items in military applications makes good business sense, the Packard Commission recommendation with respect to class S and class B integrated circuits appears to be ill-conceived and unfounded. In this light, National Semiconductor, Inc., a leader in QPL-38510 devices as well as semiconductors in general, notes the following in their Reliability Handbook.

> Many critics of government standardization programs love to point out that they are able, in many cases, to buy less expensive versions of the MIL-M-38510 device types. However, they fail to note that the less expensive devices frequently have less stringent electrical specifications than MIL-M-38510 equivalents. (In many cases they are not electrically tested over the entire operating temperature range and are manufactured with less stringent process controls or uncertified lines.) They also fail to acknowledge the fact, learned by most government agencies early in the utilization of electronics, that sensible management looks at the total cost of ownership and not merely at procurement costs [Ref. 12:p. 95].

Coming from such a distinguished manufacturer in the field of QPL-38510 integrated circuits, the above quote would seem to strengthen the argument for retaining MIL-M-38510 and significantly weaken the Packard Commission's statement that "industrial consumers of microchips have come to demand

equivalent standards" as DOD [Ref. 5:p. 61]. If industrial consumers did have equivalent standards as DOD, there would be no need for MIL-M-38510 or QPL-38510 because all devices would be manufactured to those standards! As evidenced by the National Semiconductor quote, that currently is not the case. Additionally, the claim by the Packard Commission that "military microchips typically lag a generation (3 to 5 years) behind commercial microchips" appears to be a patently exaggerated embellishment in that no factual evidence could be discovered to support that generalization [Ref. 5:p. 60].

The Packard Commission's official position states that "rather than relying on excessively rigid military specifications, DOD should make much greater use of components . . . available 'off the shelf'" [Ref. 5:p. xxv]. For many items, this is a sound procurement philosophy. Again however, this generalization cannot apply to class S and class B integrated circuits for the myriad of reasons enumerated in previous chapters. Further re-enforcement of this claim can be found in the officially stated posture of National Semiconductor with regard to MIL-M-38510.

> The rigorous schedule of quality conformance testing of the MIL-M-38510 program assures the user of long term reliability. The user is spared the expense of researching and preparing his own procurement document and of performing his own qualification testing. The QPL tells him which suppliers have qualified the device he requires and gives him a choice of qualified suppliers for fully interchangeable devices. The availability of multiple sources guarantee competitive pricing, typically lower than pricing for devices to a user's own

> specification. Since 38510 is handled by most manufacturers as a stocking program, procurement lead time will normally be shorter. The program (MIL-M-38510) is extremely cost effective. A user can purchase devices for engineering and prototyping and know that they will be identical to the devices he will get during production. When the cost factors associated with spec writing, supplier qualification, maintaining voluminous parts control documentation and the time lost due to the lack of non-standard part availability are totalled, use of the JAN ICs (QPL 38510 devices) is overwhelmingly the most cost effective approach. [Ref. 12:p. 42]

In view of the above, it would certainly appear that the Packard Commission failed to adequately research both the DOD view and those of major manufacturers with respect to MIL-M-38510 and QPL devices in general. The view held by National Semiconductor in this matter is completely congruent with that of DOD, specifically RADC and DESC. It would seem that major manufacturers of QPL-38510 devices do not regard MIL-M-38510 as an "excessively rigid" military specification as alleged by the Packard Commission, but rather as a sound engineering and cost effective approach to providing the most reliable integrated circuits for the stated needs.

The fact that the Packard Commission based its recommendation with respect to the integrated circuit issue on such a simplistic model as the automotive or Delco model seriously undermines the credibility of the Commission in this area and invites further scholarly perusal of other recommendations set forth by this Commission. To accept at face value the very notion that commercially procured integrated circuits can be readily substituted for class S

or class B devices requires a quantum leap of faith which no individual possessing a sound engineering background would make.

## C. SUMMARY

The purpose of this thesis has not been to decry the Packard Commission in any fashion. To the contrary, the Commission served as a valuable vehicle by which a distinguished group of non-military individuals, after examining DOD management practices, made recommendations which caused DOD managers to review with great circumspection how business was being conducted within the organization. In the particular case of the integrated circuit however, it appears that the Commission sorely missed the mark. Throughout this thesis, testimony has been presented from both the DOD managers of integrated circuit procurement and management (RADC and DESC) as well as a major supplier to DOD from private industry (National Semiconductor, Inc.). It has been demonstrated by the preponderance of evidence from both sides of the issue that without question, QPL-38510 class S and class B integrated circuits are significantly more reliable than commercially procured devices. More importantly perhaps, they are currently without commercial peers. Additionally, the MIL-M-38510 qualification procedures to list a device on QPL-38510 is, by even the industry's own admission, the most

cost effective way to ensure quality, reliability, performance and a ready source of supply.

Currently, class S and class B integrated circuits carry a procurement price tag which appears to be significantly higher than a commercially procured device. Although there are many contributing factors, the prime one appears to be the cost to a semiconductor manufacturer of maintaining a manufacturing facility within the confines of the continental United States for the sole purpose of producing QPL-38510 devices. Exacerbating the issue further is the low volume of production required by DOD to meet its needs. From a position of overview where all costs are considered however, the price for a class S or class B integrated circuit is not that expensive. Furthermore, compliance with MIL-M-38510 does not appear to adversely impact the availability of these devices. While the search for a more inexpensive procedure to produce and procure devices with the required parameters of a class S or class B device must be continued, great caution must be exercised by those in a position to effect change to preclude changes that would adversely impact on DOD's ability to rely totally on devices obtained for military application.

## D. RECOMMENDATIONS

In an effort to enhance savings to DOD in the procurement of equipment, original equipment manufacturers (OEM) must be held liable for utilization of QPL-38510 class

S and class B devices where required. This could be accomplished contractually by disallowing funds for the procurement of non-standard integrated circuits. Rather than giving an OEM a blank check in the area of integrated circuits, this recommendation would force the OEM to utilize QPL-38510 devices. In addition to utilizing the less costly QPL-38510 devices (as opposed to a source control drawing device), this would aid in the standardization of integrated circuits currently in service within military equipment.

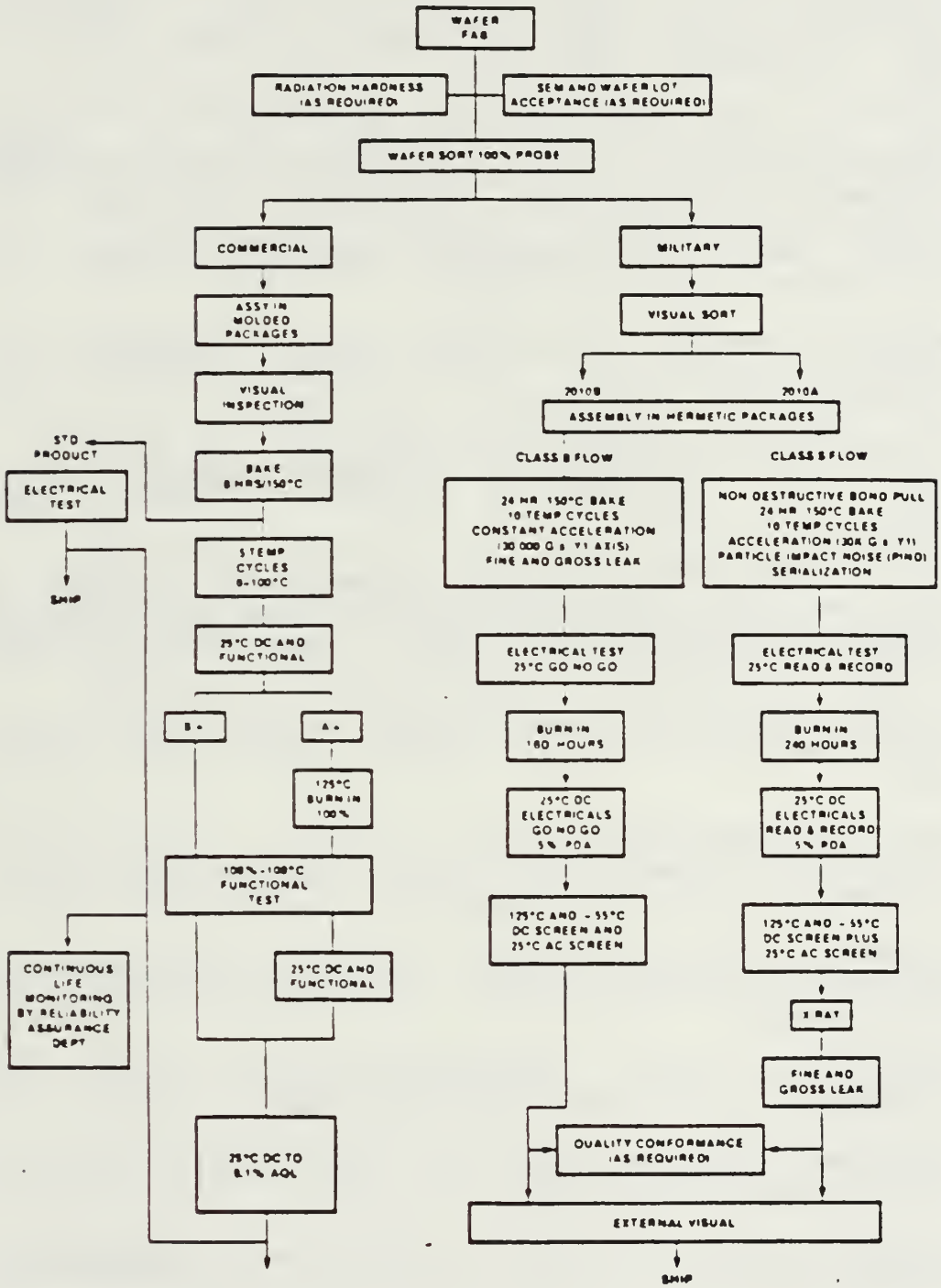
In addressing the issue of low volume DOD requirements, the following recommendation should be explored further. That is, instead of relying on multiple class S and class B integrated circuit manufacturers, one manufacturer could be identified and used to supply QPL devices for a period of one year. A possible vehicle for the implementation of this recommendation in accordance with the Federal Acquisition Regulations would be the utilization of an indefinite quantity contract awarded following competition between certified QPL-38510 manufacturers. Under the auspices of DESC, this type of program would consolidate and greatly increase the required volume of integrated circuits thus driving down the price per unit to DOD.

Finally, designate DESC as the single department procurement agent for integrated circuit procurement. This would allow DESC to control OEMs effectively by screening their request for circuit types and reducing the number of

source control drawing parts, while in the long run standardizing the integrated circuits currently in use.

# APPENDIX

## DOCUMENTATION FLOWCHART




Source: [Ref. 12]

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